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ORIGINAL ARTICLE

Which “culture”? A critical analysis of intercultural communication in engineering education

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Abstract

Background: It is increasingly acknowledged that technical expertise is not sufficient for engineers today, given the complex intercultural global contexts in which they are required to work. This article, therefore, examines how the concept of culture is typically operationalized in engineering education and discusses possible reasons for this approach.

Purpose/Hypothesis: The specific research question explored here is “How is culture conceptualized in engineering education?”

Design/Method: To examine this previously unasked question, a mixed-methods methodology was developed, one that uses both quantitative and qualitative tools. More specifically, a corpus-assisted discourse analysis of relevant engineering education articles published in leading academic journals between 2000 and 2015 was combined with a close reading of each and a critical discussion of two representative articles.

Results: Our findings reveal that, first, intercultural communication has not received the attention it deserves, given the multidisciplinary, diverse, global nature of the engineering profession. Furthermore, when intercultural concerns are discussed, the predominant approach is essentialist, meaning that culture is regarded as given (rather than constructed), framed in terms of differences between nations and potentially offering a causal explanation for individual behavior. This approach has been criticized for reinforcing stereotypical thinking and offering simplistic answers to complex problems.

Conclusions: We conclude by exploring reasons for the relatively wide-spread acceptance of the “culture-as-given” approach in engineering education, then by urging educators to adopt a “small culture” approach for constructing culture in engineering, and finally by suggesting alternative ways for developing intercultural communicative competence.

KEYWORDS

culture, discourse analysis, inclusivity, intercultural competence, interdisciplinarity

1 | BACKGROUND OF THE STUDY

1.1 | Calls for intercultural communication from the engineering field

As in other profession-oriented academic programs, there has been a serious and constant concern that engineering programs inadequately prepare students for the professional world. A study conducted by researchers from eight leading engineering schools in Brazil, China, Germany, Japan, Switzerland, and the United States concluded:

Despite their diverse histories, cultures, economies, and engineering infrastructures, it is apparent that all six countries recognize the need for a dramatically different kind of engineer and, remarkably, they agree substantially on their desired traits. The highly-analytical, technically-focused engineering “nerd” is a person of the past. They seek engineers who are technically adept, culturally aware, and broadly knowledgeable. . . . What they seek is a global engineer. (Global Engineering Excellence Initiative, 2006, p. 32)

Indeed, engineering companies, professional organizations, and accreditation bodies alike have consistently and increasingly called for graduates with effective communication skills that enable them to collaborate with a diversity of people in a globalized professional environment.

As a growing number of employers expect to hire engineers who are well versed in intercultural communication, professional engineering organizations have emphasized the necessity for engineers to possess a core set of social skills. The U.S. National Academy of Engineering (2004) acknowledged that while engineering has always engaged multiple stakeholders, it would “increasingly involve interdisciplinary teams, globally diverse team members, public officials, and a global customer base” (p. 55). Similar voices can be heard at the Royal Academy of Engineering in the United Kingdom (2007), which draws attention to the fact that in addition to technical abilities and attributes, engineering businesses increasingly demand “the ability to work in globally dispersed teams across different time zones and cultures” (p. 4). Yet, the engineering profession may find it difficult to achieve these expectations. For one, the professional challenges in engineering tend to be more complex than in many other sectors (see, for instance, Handford & Matous, 2015, on the specific communication challenges in the construction industry). Moreover, the lack of diversity within the engineering profession, not only in a national or ethnic sense, has been identified as a possible issue affecting the ability of the profession to respond adequately to societal changes (Royal Academy of Engineering, 2016).

The chorus of growing concern has not fallen on deaf ears within engineering education and has been addressed by several engineering federations and accreditation agencies. For instance, ABET (2015) and the European Network for Engineering Education (EURANEE, 2015) both stipulate that engineering graduates should understand “the wider multidisciplinary context of engineering” (EURANEE, p. 7) and “the impact of engineering solutions in a global [. . .] context” (ABET, 2015, p. 27). They should also be able to “function effectively in [an] international context” (EURANEE, p. 8). These two agencies are joined by the Federation of Engineering Institutions in Asia and the Pacific (FEIAP, 2010) in their calls for engineering professionals who “have the skills and attributes to communicate and work in teams with professionals in wide ranging fields” (p. 12). Accepted revisions to the current ABET (2015) criteria put further emphasis on communication in complex and changing times, stating that upon graduation, engineering bachelors should be able to “communicate effectively with a range of audiences” and to function effectively on teams that “analyze risk and uncertainty” (p. 24). Furthermore, starting in 2019–2020, one of ABET's new criteria will be “an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors” (ABET, 2018). Although none of the actors discussed here explicitly refers to *intercultural*, they clearly imply the necessity of such knowledge and skills through references to the multidisciplinary, international, dynamic, and global nature of the engineering setting. However, engineering schools with their predominance of men from similar backgrounds (Ouimet, 2015) may not provide an ideal setting for developing such competence.

This awareness has prompted engineering educators to develop, implement, and report on a variety of educational interventions. The current study provides a critical analysis of the linguistic descriptions of such interventions, arguing that change is needed in engineering education. It was conducted by an interdisciplinary team involving researchers with disciplinary backgrounds in engineering, intercultural communication, and applied linguistics from universities in the United Kingdom, Belgium, Australia, and Japan; this combination of skills and perspectives allows us to examine how culture is operationalized in engineering education and to discuss possible reasons for and implications of the findings. We argue that although these are crucial issues for 21st century engineering because the ability to successfully navigate and leverage intercultural situations can facilitate successful outcomes in the real world, many current educational approaches do not develop such abilities.

We demonstrate the value of explicit theoretical awareness when considering pedagogical approaches and that the operationalization of different theories of culture has practical, valuative, and even normative outcomes. It is the first study of its kind in engineering education and perhaps beyond to critically examine the teaching of intercultural communication across a representative range of studies and, to our knowledge, also the first to explicitly argue for a change of approach in engineering education. To gain insight into how intercultural communication has been conceived and implemented in engineering programs, the authors have tracked and analyzed publications in journals of engineering education and intercultural studies between 2000 and 2015, critically analyzing their theoretical stances using a novel, mixed-methods approach.

1.2 | Approaches to intercultural communication in higher education

Intercultural communication has been approached from two widely different, arguably mutually exclusive, perspectives in higher education (Holliday, Kullman, & Hyde, 2017), reflecting different ways in which culture has been framed (Goffman, 1974). The first approach frames culture as a given, the second as a construct. The culture-as-given approach focuses on describing the cultures of predefined groups, often based on nationality, as a way of providing footholds for cross-cultural interaction. Indeed, the Global Engineering Excellence Initiative quotation discussed at the beginning of this paper is framed in such terms: the nation is seen as the fundamental cultural category, and culture is perceived in terms of differences from other (national) cultures. This approach has been influenced by Hofstede, Hofstede, and Minkov (2010), who since the 1970s have used primarily quantitative methods to define dimensions of national cultures (e.g., power distance and individualism) on which countries are scored and compared. Their writing has gained wide support and has inspired intercultural education to this day, especially in organizational theory and business publications (e.g., Meyer, 2014; Trompenaars & Hampden-Turner, 2012) through which these ideas are likely to reach engineering students who seek to add a global business component to their studies.

Models derived from the culture-as-given approach are often presented and used as convenient compasses for interacting with foreigners and for overcoming national differences. Yet, this “differentialist” view of communication has been criticized for epistemological and ontological reasons (Pieterse, 2015). In addition to methodological critiques on how the posited dimensions of culture have been identified in Hofstede's work (McSweeney, 2002), there has been wide criticism of the ontological assumptions of the culture-as-given approach, including the representation of culture as a real entity with characteristics that are assumed to apply to all members of a particular group. Therefore, Holliday (1999, 2013) and others have referred to this approach as essentialist in nature. Further, by categorizing individuals using a single, usually national, identity, this approach has been criticized for being reductionist, in that it conveniently ignores multiple other identities that people typically have. Critics have additionally targeted the usefulness of this approach, arguing that what is statistically significant at the level of the group may be of little guidance when it comes to interaction between individuals. It simply cannot be posited a priori that a person will possess certain beliefs, uphold certain values, or act in certain ways because of the group they are assumed to represent. Hence, the culture-as-given approach could in some cases reinforce stereotyping and is prone to result in “narratives of inability,” preventing people from working from their strength (Holliday et al., 2017, p. 53).

Rather than framing cultures as distinct entities that define, let alone determine, behavior, the second approach toward intercultural education considers culture as a process in which meaning is jointly constructed (Dervin, 2009). This approach, which we refer to as the culture-as-construct approach, views culture as something “liquid” that cannot be reduced to a unitary, homogeneous identity (Bauman, 2007), even if it may sometimes appear solidified in social, legal, or other structures. “Cultures,” Holliday et al. (2017) write, “can flow, change, intermingle, cut across and through each other, regardless of national frontiers, and have blurred boundaries” (p. 3). Consequently, it makes little sense to try and define the cultural dimensions of one or another prearranged group. Instead, a more grounded approach is called for in which “the examination of authentic interaction, at least, can precede categorisation, as far as possible, not the other way round” (Young & Sercombe, 2010, p. 186). Such examination can, for instance, be conducted by studying discourse in the context of communities of practice, in which people with shared concerns and aims gather and learn to improve their practices through interaction (Lave & Wenger, 1991).

Consider, for example, studies in emerging discourse and behavior in the context of an engineering project that brings diverse individuals together for its duration (Handford & Matous, 2015). Such collaborations are examples of what Holliday (1999) would refer to as the “small culture paradigm” which approaches culture in the ethnographic tradition “as an interpretive device for understanding emergent behavior rather than seeking to explain prescribed ethnic, national, or international difference” (p. 237). Researchers working within this paradigm, therefore, need to be mindful of the particularities of each situation with an eye for what connects and separates people in a given encounter as well as the individual's ability to shift between different cultural identities. Although material that can be situated in the culture-as-construct approach has become

increasingly available for professionals in higher education (Hoffman & Verdooren, 2018; Holliday, 2013; Holliday et al., 2017; Piller, 2011; Zhu, 2014), these authors primarily address students of applied linguistics and social studies.

1.3 | Research question

In this paper, we examine how the teaching of intercultural communication is approached in engineering education, discuss the reasons for and the implications of the predominant approach, and recommend an alternative one. The overarching research question that we ask is “How is culture conceptualized in engineering education?” Specifically, “Is the conceptualization more in line with culture-as-given approaches or is it more in line with culture-as-construct approaches?”

This research question will be addressed by conducting a corpus-assisted discourse analysis (CADA), a close reading of the individual papers and a discussion of the findings from two representative papers about the conceptualizations of keywords related to culture in engineering education research. The wider significance for the development of intercultural communication in engineering education is further explored in Section 4, where we discuss the possible reasons for the conceptualization of culture that is favored in engineering education and the implications of this tendency, followed by recommendations that can be offered to engineering educators on the basis of our findings.

2 | METHODOLOGY

This methodology section comprises the data collection, focusing on a description of how the papers were selected followed by the data analysis, which includes a description of CADA, the close reading, and the analysis of representative papers. To date, we have found no instances of corpus-informed studies in engineering education, and the combination of the methods used here was developed to allow the research question to be effectively addressed within the constraints of a single research article. Furthermore, a purely quantitative approach would permit only a rather superficial understanding of the data, and a purely qualitative approach would be open to accusations of “cherry-picking” and unrepresentativeness. By combining these quantitative and qualitative methods, our findings are both representative and fine-grained.

2.1 | Data collection

An initial search using the SCImago Journal and Country Rank for journals in the fields of engineering education and intercultural studies yielded 61 journal titles, from which we selected the 12 most established general journals based on their impact, particularly in the domain of education. Intercultural journals were also considered because they have published several important studies in engineering education. Next, searches for “inter-” and “cross-cultural” in the engineering education journals, and for “engineering” in the intercultural journals yielded 49 and 261 papers, respectively, published between 2000 and 2015. All papers were manually scanned for the extent to which they address intercultural learning in engineering education, resulting in a final set of 31 papers, distributed as seen in Table 1. This collection, or corpus, of articles that we refer to as the Journal Articles of Intercultural Communication Engineering Education (JAICEE), totaled 205,544 words. Research quality (Borrego, Foster, & Froyd, 2014) was not explicitly assessed when compiling this corpus as our interest was in the underlying assumptions of the investigations and education practices reported in the articles. Nevertheless, all appeared in leading international journals.

By explicitly focusing on the language used in these papers, we can interpret underlying discourses of culture (in other words, ways of constructing culture as a concept through language) and ways that intercultural is framed in the discourse. This interpretation was achieved through CADA, as described below.

2.2 | Data analysis

CADA is a mixed-methods linguistics methodology that combines quantitative tools from corpus linguistics and qualitative tools from discourse analysis (Baker, 2006; Sinclair, 2004). This approach employs statistical measures to identify important linguistic items, which are then interpreted using longer extracts of text. It has been applied in a range of fields, including media discourse (e.g., O’Keeffe, 2006), gender studies (Baker, 2014), business communication (Handford, 2010), and intercultural communication (Handford, 2014; Zhu, Handford, & Young, 2017). The advantage of this methodology is that it allows for a reduction in the potential research bias typically associated with qualitative approaches in the analysis of texts, while enabling a contextual appreciation that a purely quantitative study would not permit. However, despite the demonstrable advantages and epistemological attractiveness of this approach, to our knowledge, CADA has not been employed in

TABLE 1 Origin of the academic papers (2000–2015) on intercultural learning in engineering education in the JAICEE corpus

Engineering education journals	27
<i>Journal of Engineering Education</i>	5
<i>International Journal of Engineering Education</i>	–
<i>European Journal of Engineering Education</i>	15
<i>Journal of Professional Issues in Engineering Education and Practice</i>	3
<i>Advances in Engineering Education</i>	4
Intercultural studies journals	4
<i>International Journal of Intercultural Relations</i>	2
<i>Intercultural Pragmatics</i>	–
<i>Journal of Intercultural Studies</i>	–
<i>Language and Intercultural Communication</i>	–
<i>Intercultural Education</i>	2
<i>Journal of Intercultural Communication Research</i>	–
<i>Journal of International and Intercultural Communication</i>	–

engineering education contexts. Furthermore, the methodology used here is novel, as it combines CADA methods with two further steps: an initial close reading of each article, followed by a discussion of two representative articles. The initial reading focuses on the question, “Does the paper employ a culture-as-given or a culture-as-construct perspective?” and the final step discusses two papers, each representing one of these perspectives.

The combination of CADA with this close reading and discussion of two representative papers has the potential to create a degree of redundancy. However, whereas the close reading allows for a broad-brush interpretation of each article and the representative analysis “drills down” into two articles, CADA reveals patterns across texts as patterns specific to single texts. Such patterns are, of course, linguistic, for example frequent and typical words, and suggestive of shared approaches to the same issue. But they can also imply contextual patterns, reflecting the stance of writers toward a particular item and the concepts it invokes, again across a range of texts. Such evaluative stances may also operate at a less than conscious level in the producers of texts themselves (Sinclair, 2004). It is for these reasons that we argue the combination of these steps is worthwhile.

The review framework for the close reading was inspired by Holliday, Kullman, and Hyde's (2017) concepts of small versus large cultures, which distinguish between differentialist, prescriptive/predictive essentialist (or culture-as-given), and interpretive nonessentialist (or culture-as-construct) approaches. While our primary intention was to ascertain the degree of essentialism in the reviewed studies, this review was also informed by an assessment of the degree to which essentialism is explicitly articulated in each paper. Such an assessment is important because many approaches may be considered as neither clearly essentialist nor clearly culture-as-construct, because they either include (a) both explicit essentialist elements mixed with culture-as-construct elements or (b) neither explicit essentialist nor culture-as-construct indicators. The discussion of representative papers involved choosing two articles that, rather than representing what is typical across the corpus (which CADA shows), examine articles which are representative of the two positions discussed here in terms of linguistic patterns and argumentation. We argue this methodology allows for a high degree of triangulation and a more plausible interpretation of the data than a single-method approach would allow.

The software used to produce the quantitative results was Sketch Engine (Kilgariff et al., 2014), and the corpus tools employed are “keywords” and collocation analysis. Keywords in Sketch Engine are produced by dividing the normalized (per million) frequency of each word in the target corpus (JAICEE) with the normalized frequency of the same word in a much larger reference corpus, thus allowing for the identification of typical words (keywords) in the former (Kilgariff et al., 2014). Unlike pure frequency lists of single words that consistently show how functional items such as articles and prepositions are the most frequent in language, keyword lists are considerably more interesting as they highlight the characteristic and important language of the context in question (Baker, 2006). The reference corpus used here is the written part of the Open American National Corpus, chosen because it is a large collection (11,048,137 words) comprising a range of text types, thus providing a suitable base line for comparison. As there are inevitably hundreds of keywords (in this study, more than 1,000), only those considered most relevant will be discussed, specifically cognates of the keyword *culture* and the keyword *diversity*. As corpus tools cannot recognize different spelling conventions, all U.K. spellings in JAICEE were changed to U.S. conventions.

Collocation can be calculated by different means (see McEnery & Hardie, 2012), but the underlying concept concerns the relationship between words that co-occur in near-proximity to each other. For instance, in JAICEE, there is a strong collocational relationship between *culture* and *different* in that they often co-occur to form the phrase “different culture” (see Section 3.1). In another corpus, “different” may collocate more typically with other nouns.

3 | RESULTS

This section begins with CADA, providing empirical evidence of the typical linguistic patterns in the corpus of articles and the conceptualization of culture they invoke. It is then followed by the findings of a close reading of all the articles and a discussion of the two representative ones.

3.1 | CADA

While the general topic discussed here is approaches to intercultural communication in engineering education, we demonstrate that it is through the analysis of *culture* and related terms that the topic can be best understood. The reason for this approach is that the way culture is operationalized affects how it is taught and then applied in intercultural encounters, and even how we define an “intercultural encounter.” In our analysis, there are certain items of note from both qualitative and quantitative perspectives, as they are simultaneously discursively salient and keywords, respectively; in this study, we identify *cultural*, *culture*, *cultures*, and *diversity* as such items. Our use of salience, which draws on Williams' (1976) notion of “culturally key” and on Hunston's (2002) “cultural salience,” refers to language that is important in this context because it relates to the research questions, but is not necessarily frequent. Our selected keywords are both salient and typical. While further analysis of other items would be possible, such as the frequent phrases *intercultural communication* or *beliefs and assumptions*, these four items were chosen here because they most elegantly and succinctly demonstrate the typical patterns in the corpus. Table 2 shows the normalized (per million words) frequency in JAICEE and in the reference corpus for each item analyzed, showing, for instance, that *cultural* occurs 31 times as frequently in the former, while *diversity* occurs more than 9 times as frequently.

This section examines these items and their collocates to provide insights about their meaning and use. This examination involves the explicit and implicit analysis of concordance lines: explicit in the presentation of data (e.g., Tables 3 and 4) and implicit in that they allow for the production of collocation results. Concordance lines, lists of “all the occurrences of a particular search term in a corpus” (Baker, 2006, p. 71), feature several words preceding and following the search term in question and are the fundamental tool in corpus linguistics because they allow for horizontal and vertical patterns of cotext to be seen across a range of texts.

3.1.1 | Cultural

In terms of words with semantic content (unlike “functional” words), *cultural* is the fourth most frequent item in the corpus, behind *engineering students* and *learning*, occurring 507 times. This is separate from its appearance in terms like *intercultural* and *cross-cultural*. Using Sketch Engine, the grammatical and lexical profile of *cultural* can be constructed. It tends to modify nouns, by far the most frequent of which is *difference/differences* (65), the number in parentheses indicating the pure frequency of the collocation in the corpus. Other nouns it frequently modifies include *background* (34), *awareness* (17), and

TABLE 2 The statistical information for selected keywords

Keyword	Frequency in JAICEE corpus ^a	Frequency per million in JAICEE ^b	Frequency per million in reference corpus ^c	Keyness score ^d
<i>Cultural</i>	507	2,086.3	66.9	31.2
<i>Culture</i>	299	1,230.4	192.4	6.4
<i>Cultures</i>	211	868.3	72.6	12.0
<i>Diversity</i>	116	477.3	51.1	9.3

^aThe number of times a term in its particular form appeared in the engineering education papers selected.

^bThe normalized frequency of the occurrence of the term per 1 million words enabling comparisons with texts and corpora of different lengths.

^cThe frequency of the terms in the Open American National Corpus, a baseline for our comparisons.

^dThe relative frequency of the term in the engineering education papers selected compared to general English texts in the reference corpus. For example, the term *cultural* is 31 times more frequent and the term *diversity* is nine times more frequent in JAICEE than in the reference corpus.

TABLE 3 JAICEE “cultural differences” concordances

We use this model to raise awareness of	<i>cultural differences</i>	and to begin changing students' attitudes
characterize and respond to meaningful	<i>cultural differences</i>	The sessions format is a full group activity
required acceptance and understanding of	<i>cultural differences</i>	within the team
and interactional expectations. Alongside	<i>cultural differences</i>	another significant challenge for employers
how language barriers, inherent	<i>cultural differences</i>	and communication-adverse education

competence (17). One of the most frequent collocates in the modifying position is *disposition*, but a close analysis reveals that all of the collocations *cultural disposition* occur in only one article. Similarly, *norm* collocates 25 times with *cultural*, but 20 of these are in the same article. In contrast, *cultural difference(s)* occurs across 18 articles. The concern here is that by making cultural difference the key explanatory factor in intercultural engineering education, the complexity of culture is glossed over, and learners are directed toward first finding and then attributing meaning to difference, above all other aspects. This point is discussed later in this paper.

The high frequency of *cultural* and its most frequent collocational phrases such as *cultural difference(s)* means it is deserving of further textual analysis of concordance lines to allow for drawing inferences on the role it plays in the context of these articles and the educational approaches it represents. Table 3 below lists randomly chosen illustrative concordance lines from the JAICEE corpus.

A syntactic analysis can also shed light on the way *cultural difference* is framed in the discourse. It appears in both subject and object position in clauses; for example, “Cultural difference creates significant difficulties for educators,” and “We use this model to raise awareness of cultural differences,” respectively. Interestingly, the verbs that collocate with *cultural differences* in either its subject or its object position, such as *navigate*, *have*, *recognize*, *identify*, and *understand*, reflect a conception of cultural difference as a thing or a collection of things to be navigated, recognized or possessed in its object position, or which can “create” problems when used in its subject position.

The most frequent collocate of *cultural* as a modified adjective is *different*, drawing a clear parallel with *cultural* in its modifier position. Table 4 shows randomly selected illustrative concordances from the JAICEE illustrating the cotext of these collocations.

An analysis of the complete 21 concordances of *different cultural* shows that the most frequent pattern is:

(active verb) + people/students/groups from different cultural backgrounds

An example of this pattern is the phrase “the additional challenge of working with people from different cultural backgrounds.” Furthermore, the longer extracts from which these concordance lines are taken reveal that *different cultural backgrounds* are largely synonymous with “different nationalities.” Such patterns suggest that the dominant trend in JAICEE is toward a differentialist, culture-as-given approach.

3.1.2 | Culture

Using Sketch Engine to build a linguistic portrait of culture as it is used in the corpus, we find that

1. Its two most frequent collocates are *different* (59) and *other* (52); also, *own* occurs 10 times.
2. Several of its most frequent collocates are concerned with the national level, such as *nationality* (9), *country* (8), *foreign* (6), *Brazilian* (3), *American* (3), and *French* (3).

TABLE 4 JAICEE “different cultural” concordances

Needs and expectations of students from	<i>different cultural</i>	backgrounds
in a world that is composed of people of	<i>different cultural</i>	backgrounds
Pursuing active engagement with students from	<i>different cultural</i>	backgrounds
intercultural skills as the ability to understand	<i>different cultural</i>	contexts and viewpoints
Students from	<i>different cultural</i>	backgrounds had diverse conventions
interaction with peers, TAs, and faculty from	<i>different cultural</i>	and linguistic backgrounds
differences that exist among people from	<i>different cultural</i>	backgrounds

3. It forms a loosely connected category comprising two strands, one featuring items such as *engineering* (20), *disciplinary* (5), and *professional* (3), the other *organizational* (5), and *institutional* (3).
4. It is most frequently found in a modifier position, for example, *engineering culture* (20).

Based on these findings, we can posit that *culture* is typically framed in terms of difference, with 19% of its uses combining with either different or other; this pattern reflects the one found for *cultural*. The most frequent cultural category that modifies *culture* is the national; to a lesser extent, *culture* is also framed at the institutional level. Grammatically, many of these collocates are attributive adjectives, for example, *different culture* or *foreign culture*.

3.1.3 | Cultures

The collocates of *culture* and *cultures* are not always the same, even in an intercultural education context (see Zhu et al., 2017), a finding that can be explained by the context-dependence of linguistic terms, a key insight of discourse analysis (Gee, 2005). However, in JAICEE, some similar patterns are evident. For instance, the top two collocates of *cultures* are *different* (46) and *other* (42), while *own cultures* does not occur. Other noticeable collocates include *foreign cultures* (7), *national cultures* (4), and *learn/know about other cultures* (5). There was no evidence of the framing of diversity within a national culture; for instance, *U.S. cultures*, *American cultures* or *Brazilian cultures* did not occur.

3.1.4 | Diversity

Diversity was chosen here because, despite not being a cognate of culture, it may reflect a more inclusive, complex approach to the teaching of culture than is evidenced so far in our analysis of other keywords. In other words, it may involve a culture-as-construct approach. However, once again a closer analysis of the cotext suggests a somewhat critical view of diversity. The most frequent verb collocate of *diversity* is *increasing*, which may be interpreted as having positive connotations. However, an analysis of the words that occur with *increasing diversity* shows they are neutral, or even problematic, including issues of increasing student fees and loans, the growth of student numbers, and resulting pressures such as issues of relocating. Diversity is literally something to be accommodated rather than embraced or leveraged.

The most frequent noun or verb modified by *diversity* is *issues*, occurring 16 times in the corpus, although all in one article. The term *issues* itself has arguably negative connotations and is often synonymous with *problem* (Handford, 2010). A closer analysis of the texts reveals further framing of diversity as potentially problematic; for example, according to Ihlen and Gebauer (2009), students “normally get confronted with the aspects of diversity when they leave university and start their professional life” (p. 419).

Looking at diversity more generally reveals a debate over the benefits of it in the classroom. For instance, according to LaFave, Kang, and Kaiser (2015):

The trend toward greater diversity in the engineering classroom is a welcome one, but it is also one that undoubtedly poses some challenges in implementing the engineering curriculum. This can be the case especially as relates to courses having a heavy emphasis on interactive, collaborative, team based projects. (p. 1)

We argue that approaching diversity as an issue or a problematic challenge, especially in interactive courses, indicates a stance that sees diversity as an obstacle to be overcome rather than as an opportunity for synergy and creative solutions. Research into problem-solving has shown the potential benefits of diverse teams when effectively managed (Rock & Grant, 2016), and approaching diversity from such a perspective is more likely to encourage positive perspectives and involvement from learners and future professionals (see also Pawley, 2017). Doing so would clearly require a reframing of the way culture is approached in engineering, precisely the debate we hope our research will inspire.

This short selection of items and their collocations shows some trends in the way culture is perceived or projected by the authors of these articles. Clearly, *cultural* is framed primarily in terms of difference; similarly, the main collocates of the item *culture*, such as *different*, *foreign*, *other*, *own*, and *their* as well as mentions of nationalities, frame culture in terms of difference, often at the national level. As such, the keyword and collocation analyses revealed a strongly differentialist, culture-as-given approach, reflecting an essentialist stance in much of JAICEE. We argue that the framing of diversity as problematic also suggests such a stance. Considering the types of collocates that do not appear on the list, such as *similar*, *complementary*, or *corresponding*, provides insight into an alternative approach: rather than seeing culture primarily in terms of difference, a more dynamic and inclusive framing is not only possible, but we argue it is also more likely to achieve better results in intercultural

interactions. The subsequent close reading of all the articles and detailed analysis of two representative ones further illuminated the predominant stance across the corpus.

3.2 | Close readings

The literature review of the selected papers indicated a mix of approaches to culture in engineering education and research as curriculums respond to the demands of globalization. As suggested by the corpus analysis, a large proportion of studies link culture with nationality, with approximately half (15/31) of the papers taking an essentialist culture-as-given stance. These papers address the topic of culture, with the discussion focusing on educational projects in which participants were tasked to collaborate with people from other countries either directly (Arzberger et al., 2010; Jesiek, Haller, & Thompson, 2014; Mehalik, Lovell, & Shuman, 2008; Meunier, Dutto, Guillet, & Michau, 2007) or in geographically distributed virtual teams (Davies, Zaugg, & Tateishi, 2014; Gonzalez, Guerra-Zubiaga, Orta, & Contero, 2008; May, Wold, & Moore, 2015; McNair, Paretti, & Kakar, 2008; Zaugg & Davies, 2013). These authors, together with Downey et al. (2006), LaFave et al. (2015), Friesen and Ingram (2013), Hazelton, Malone, and Gardner (2009), and Soibelman et al. (2011), focus on the ability of graduates or professional engineers to work with others who have been raised or educated in “foreign” cultures (Swearengen, Barnes, Coe, Reinhardt, & Subramanian, 2002), countries, or language backgrounds.

Despite widespread acknowledgement of the complexity of culture, we did not find any engineering educational studies that both explicitly theorize culture or define intercultural competence and at the same time have broader goals beyond preparing students to work with engineers from different countries or educational systems. For example, the studies reviewed that focus on intercultural competence do not seem to consider the preparation of engineers for work with architects, designers, local authorities, bureaucrats, laborers, or other key stakeholders within a domestic context that represent various professional norms and practices despite possessing the same nationality and first language, nor were there any articles that explicitly discussed intranational diversity. There are five studies, however, that take an implicit or partial “culture-as-construct” stance by discussing the culture of engineering education itself (Godfrey & Parker, 2010; Jamison, Kolmos, & Holgaard, 2014) and exploring the intercultural (Gourvès-Hayward & Morace, 2010) or interdisciplinary (Byrge & Hansen, 2009) learning process, or the ability to “reconstruct life and culture” (Neumeyer, Chen, & McKenna, 2013, p. 1). The remaining 11 articles were not put in either category, although there was a tendency for them to implicitly or partially follow a culture-as-given approach. Because of space limitations, we briefly summarize and explain each of these articles in the Appendix.

In summary, the initial close readings supported the corpus analysis as it also showed the culture-as-given approach was more frequently applied than a culture-as-construct approach, with 15 articles operationalizing the former conceptualization and only five the latter. However, the close readings also found more variety and differences of degree across the articles than the corpus analysis suggested, revealing five articles that at least partially took a “culture-as-construct” approach. This finding supports the inclusion of the analysis of close readings, highlighting the limitations of relying solely on corpus tools, which inevitably pinpoint more frequent linguistic patterns. In other words, by prioritizing frequency, a corpus approach does not draw attention to marginal phenomena in the corpus; as a result, corpus tools are best supplemented with more such fine-grained methods like the close reading done here.

The final part of our analysis involved drilling down into the corpus and choosing two articles, each typical of one of the two approaches to culture explored here. The first article by Downey et al. (2006) is arguably the most influential in the sub-field of intercultural engineering education: it is the most widely cited article in the corpus (more than 320 citations, according to Google Scholar) and the top article in the *Journal of Engineering Education* under the search term “intercultural.” Based on the close readings, it was, therefore, chosen as an exemplar of the “culture-as-given” perspective, and a close analysis of the language in the paper suggests that it takes a differentialist stance; for instance, the words *different* and *differently* occur 73 times compared to an average of 16 across the corpus, and “different countries” occurs 14 times compared to an average of just over once per article.

As is the case with many recent studies of intercultural communication, it overtly eschews an essentialist stance, only to take up a neoessentialist one (Holliday, 2013). For example, the article begins by recognizing the complexity of the modern world and the dangers of stereotyping, then argues that the solution is to focus on the national level: “The key point has to do with countries. . . . Even if other countries do not have single cultures, they nonetheless provide high-probability sites for encountering unfamiliar ways of thinking about engineering work” (Downey et al., 2006, p. 2). The paper outlines an approach for teaching culture, which tests the learner's ability to predict behavior based on national differences in engineering.

The authors define the following learning outcomes: (a) Students will demonstrate substantial knowledge of national patterns in engineering knowledge and engineering work; (b) Students will demonstrate an ability to analyze how national

differences are important in engineering work; (c) Students will demonstrate a predisposition to engage engineers from other countries as coworkers who have knowledge, value, and points of view, and to expect to accommodate their own perspectives to those of other engineering problem-solvers.

In other words, while the focus is on engineering, as one would expect in engineering education, the lens through which the problems are perceived is a national one. An example activity asks students “to imagine themselves as Japanese engineers working with Americans on a given project, describing likely conflicts among Mexican engineers” (Downey et al., 2006, p. 8). Given the assumptions in this approach, we believe that students with a high degree of cultural sensitivity would be more likely to fail this course than those with rigid stereotypes. In other words, the course is likely to reinforce the perceptions of a priori assumptions in individual intercultural situations and encourage the type of behavior that can lead to unsuccessful communication.

A paper by Gourvès-Hayward and Morace (2010) is the example in our corpus that appears to come closest to a “culture-as-construct” approach. With just 14 citations in Google Scholar, the paper is also indicative of the limited influence that this approach has had compared to more essentialist voices. Rather than interpreting communication primarily through a national lens, this paper provides a cultural analysis at multiple levels. In addition to the country level, the authors consider the cultural context of their study from different educational levels, that of the *Grandes Ecoles* (elite French graduate schools of engineering and management) as well as the specific institutional and classroom contexts in which they conducted their research. A close analysis of the language in the paper supports this more inclusive stance. In contrast to Downey et al. (2006), where phrases like *different countries* and *different cultures* appear frequently, each of these word combinations occurs just once in this paper. Interestingly, the notion of difference is still present, but the authors, who were inspired by Demorgon's (2004) multiperspectivist theory, extend it to comprise the additional perspectives of “field,” “level,” “strategy,” and time (“diachronic”).

Regardless of the number of perspectives that are distinguished, a culture-as-construct approach is characterized foremost by its recognition of the liquidity of culture. In this regard, Gourvès-Hayward and Morace (2010) borrow from theories of liminality (Bhabha, 1994; Kramsch, 1993), which consider how cultural identities are not only preestablished but also negotiated in the interaction itself in the awareness that intercultural dialogue does not so much “involve a search for bridges but for an understanding of the boundaries” (p. 304).

This theoretical frame is also apparent in the teaching design of the experiential intercultural management course that the authors report. Introductory classes are followed by a three-day business game with home and visiting students, one that involves directly experiencing conflict, consensus and mediation, closely resembling professional situations. During and after the process, students are asked to reflect on their own behavior as an intercultural team, and together with the teacher, they analyze the complexity of their intercultural experiences from the different perspectives listed. Nevertheless, this paper still bears traces of a culture-as-given approach as, for instance, when the authors explain the initial refusal by a teacher with a UK background to comply with one of her student's requests as “partly due to [her] culturally biased wish to conform to a more rule-based model (UK) in order to avoid chaos and promote fairness” (Gourvès-Hayward & Morace, 2010, p. 309).

4 | DISCUSSION

This paper has asked an important, timely question about intercultural communication in engineering education, placing an understanding of the word *culture* at the center of the analysis. Culture, seen as one of the most problematic words in the English language (Williams, 1976), can be defined and applied in contrasting, arguably mutually exclusive ways. In studies of intercultural communication, two frequently contrasted approaches are defined here as culture-as-given and culture-as-construct, with our analysis exploring which of these is prevalent in the data. We found that the tendency is for educational programs in engineering to favor a culture-as-given approach, one that involves an essentialist, differentialist perspective, with nationality as the defining difference. This approach is reflected in both frequent and typical linguistic items and their collocates, evidenced through the corpus linguistic quantitative analysis and in the overall arguments revealed by a qualitative, whole-text reading of all the articles. In this section, the potential issues with the culture-as-given approach are further discussed, and we propose reasons why engineering education may favor such an approach. In the following section, brief and practical suggestions for an alternative are presented.

As we discussed in Section 3, culture tends to be framed primarily in terms of difference and cultural difference as something to be explored, understood, and applied when conducting interactions. This framing of cultural difference in itself is an instance of “reification,” which is “the process of giving form to our experience by producing objects that congeal this experience into

'thingness' and then attributing such meanings an existence independent of people" (Wenger, 1998, p. 57). According to Holliday (1999), "in the case of culture, reification takes place where the notion of culture has been constructed for the purpose of explaining behaviour, but is then institutionalized into something that exists over and above human behaviour" (pp. 214–242). This appears to be the case in much of our data, indicating that research and courses on intercultural communication in engineering education primarily rely on the assumption that culture is something that can dictate behavior, rather than an abstraction of a changing, dynamic, and context-specific set of practices.

The problem with the reification of cultural difference, therefore, is that it is a category error. Grammatically, it often appears as an active agent, the subject of active verbs: in other words, "cultural difference" is portrayed as a causative agent whereas in fact culture itself is an "abstract and purely analytical notion. It does not cause behaviour, but summarizes an abstraction from it" (Bauman, 1996, p. 11). Holliday (1999) goes on to argue that after the process of reification, "culture appears large and essentialist, and indicates concrete, separate, behaviour defining, ethnic, national and international groups with material permanence and clear boundaries" (p. 242). This pattern is also seen in our data: a large number of collocates of our analyzed keywords include nation-related items; in other words, there is a strong focus on difference, often in terms of different nations and nationalities. These findings were largely supported by the close readings.

A possible response to these points questioning the validity of framing culture in terms of difference, and difference at the national level specifically, is "but surely it is natural that culture is seen in terms of difference in this context, as intercultural communication is often defined as the study of communication between people of different cultures." We argue that an awareness of cultural difference is important, but it is only one aspect of developing intercultural communicative competency; moreover, an overemphasis on culture in terms of difference, as seems to be the case in many of the articles analyzed here, may actually lead to unsuccessful intercultural communication through reification, stereotyping, and otherization. Similar to the emphasis on cultural difference, usually framed in national-level terms, the national culture itself is often framed in monolithic terms as evidenced by the absence of terms such as "U.S. cultures." While the lack of expressions like "American cultures" may seem common sense, we argue that it is only common sense in terms of accepted perceptions of cultural stereotypes applied to nations. For learners to be flexible intercultural agents, a greater understanding of the dynamism, complexity, granularity and downright slipperiness of culture, both our own and others', is prerequisite. It should also be noted that this alternative approach to culture is not new and has been cited in studies preceding the articles in JAICEE (e.g., Bhabha, 1994; Kramsch, 1993; Sarangi, 1994).

This discussion raises the question "Why does engineering education tend to favor the culture-as-given approach?" The first point to consider is that several other academic disciplines also rely on essentialist understandings of culture, drawing particularly on the work of Hofstede (e.g., Hofstede et al., 2010). These include behavioral science, organizational studies, management studies, and psychology; in contrast, other disciplines that historically have had a longer and more extensive engagement with "culture," such as anthropology and sociology, eschew such an approach (Baskerville, 2003). Baskerville (2003) argues that the disciplines that favor an essentialist stance are concerned with individual responses to problems or stimuli. These disciplines explain and to varying degrees predict these responses, and the explanation and prediction of responses to stimuli and problems in the real world are also central concerns of engineering. The attractiveness of a culture-as-given approach may partly lie in that promise of positivistic predictability. However, the problem is that accurate predictions of individual behavior based on nationality or other collective-level categories is typically not possible and may even cause offense to the individual concerned. We are all multiply membered in different groups, and these different identities become relevant, are problematized, or can hybridize at different moments of our day. Furthermore, framing the national as the fundamental cultural identity and attributing any perceived differences in behavior to individuals' nationality means that other identities and professional or intranational diversity may be overlooked.

It is also important to briefly consider the wider sociopolitical context in which engineering education and practice occur and which, inevitably, strongly influences the "cultural" education of engineers. For instance, we might consider the dominance of engineering education by a corporate ethos in which the professional independence of engineers and associated view of the public interest has all but disappeared to the benefit of a corporate instrumentalism. Layton, in analyzing the U.S. context, argues this change occurred in the early 20th century; he states, "The engineer is both a scientist and a businessman. Engineering is a scientific profession, yet the test of the engineer's work lies not in the laboratory but in the marketplace" (Layton, 1986, p. 1). While it is unclear whether this tendency is prevalent across the globe, which is an important question in itself, it is arguably so in the dominant Anglophone world from which our data are drawn. Moreover, this move to corporatism in engineering reflects the wider neoliberal ideology under which institutions including universities operate and in which "culture" is construed as a commodity to be traded or a barrier to capitalist expansion of markets that needs to be overcome (Bourdieu & Wacquant, 2001). The reification of culture inherent in the culture-as-given approach enables culture to be seen as a commodity or obstacle, hence its attraction to

engineering education in neoliberal society. Framing culture as amorphous, slippery, and dynamic could not lend itself to such conceptions.

The question of why so many engineering educators in our review seem to prefer the culture-as-given approach is important, but one potentially fraught with dangers. Attempting to answer it can invoke essentialist stereotypes about engineers that may not be accurate. Gambetta and Hertog (2009) argue that “engineering as a degree might be relatively more attractive to individuals seeking cognitive ‘closure’ and clear-cut answers as opposed to more open-ended sciences. . . . Engineering is a subject in which individuals with a dislike for ambiguity might feel comfortable” (p. 21). Of more interest to us than this argument about self-selection is their argument that engineering education itself could, if changed, encourage students (and future engineering educators) to adopt a less mechanistic view of culture and society. Currently, socialization into engineering practices prioritizes a rational control of processes, thus making engineers less able to navigate the confusing complexity of the social environment, while inculcating expectations for society to function along orderly, predictable lines (Gambetta & Hertog, 2009). We briefly outline some aspects of an alternative approach below.

5 | IMPLICATIONS FOR PRACTICE

We believe that the culture-as-construct approach can inspire more effective educational practices and programs for engineers that would better prepare the students to work in complex social environments and attract new students with more diverse interests. In this final section of our paper, we outline several key tenets of a culture-as-construct approach to engineering education including examples. Such an approach should prioritize the following.

“Small cultures” over nationality. Intercultural education and training should go beyond recommendations on how to deal with people of different nationalities and ethnic groups. A presumption of national homogeneity and an emphasis on international difference do not improve intercultural competence. Culture is not an attribute of “foreign people.” Students should be directed to reflect on and to discuss the cultures of small groups and institutions that they belong to, and try to better understand from where their own worldviews originate. It is important to accept that becoming adept at reflecting on one's own thinking is a life-long process that cannot be mastered in a single program, let alone one semester. At the university of one of the authors, all students and staff are encouraged to nurture the habit of reflection on what is termed “cultural competence,” an initiative supported by university-led training.

To enhance students' cultural competence, this university provides students opportunities to participate in projects within rural communities (not necessarily overseas) during which engineering students tackle complex social issues in teams with students from the humanities. A strong emphasis is placed on understanding the social significance of the project and, most importantly, the social context within which each project is embedded. The preparation for these off-campus team project activities includes predeparture workshops aimed at minimizing students' uninformed ethnocentric, patronizing, or voyeuristic views that fetishize the culture of people in the visited communities, which for some students is the reason why they were attracted to such projects in remote locations. The resources on the website of the National Centre for Cultural Competence (2018) at the University of Sydney provide such training for the students. It needs to be noted that many of the students' most challenging interactions are with domestic interlocutors and, thus, would not be classified as intercultural training if framed under the traditional approach. We argue, however, that domestic contexts can provide rich intercultural learning environments.

Coconstructive interpretivist understanding over prediction. While engineering and natural sciences are traditionally concerned with design and predictions based on causal models, such an approach is unlikely to be helpful for predicting individuals' behavior based on their affiliation to large prescribed entities such as nation states with high variations within these categories. Although engineering students and busy practitioners often favor simple rule-based recommendations that claim to increase intercultural competence, the tastiest medicine is not necessarily the most effective—indeed it rarely is! Many collaboration and communication partners do not want to be treated as the average of a large category based on their nationality or ethnicity, or be reduced to some other perceived generic label that classifies them into the “other” category.

In pedagogic terms, addressing this issue involves encouraging learners to embrace complexity over reductionism. The authors of this paper have designed workshops in collaboration with industrial partners that use case studies of complex issues encountered by engineers in relation to intercultural communication. These cases include examples in which assumptions about the “other” culture have led to stereotyping and poor cooperation. The students work on the case studies together to collectively interpret the situation introduced. A large part of these activities is dedicated to unlearning students' previously acquired essentialist approaches to intercultural interactions that most engineering and project management students have been exposed to in their past studies.

6 | CONCLUSION

This paper investigated how “culture” is conceptualized within the context of engineering education, why it may be so, and the implications of these findings. In so doing, it has demonstrated the theoretical relevance of conceptions of culture in engineering education and has provided original empirical findings for the predominant educational approach, which we argue is essentialist. We have discussed reasons for, and highlighted the concerns around this approach and suggest an alternative.

This research was conducted by an interdisciplinary team with a range of skills and from different disciplinary and cultural contexts, but with a shared interest in the topic; we argue that this study could only be effectively addressed by such a diverse team, and it is the interdisciplinary nature of the work that has been foundational to the original contribution of the research. Furthermore, an innovative methodology was developed and applied, combining qualitative and quantitative textual analyses of a corpus of engineering articles to examine the way culture is conceptualized in engineering education. The analysis was conducted on all 31 papers identified that focus on intercultural issues in engineering education published between 2000 and 2015. This number of articles, unexpectedly small given the importance of the topic, may reflect insufficient concern with intercultural communication and related issues in research on engineering education.

The interdisciplinary approach (Wray & Wallace, 2015) used here has, thus, drawn on methods and theoretical concepts developed primarily in applied linguistics and cultural studies, applying them to an engineering-education context. While this study has focused on engineering education, we believe that other disciplines may benefit from such an analysis, given the importance of the intercultural in contemporary society.

While this study has demonstrated the theoretical relevance of conceptions of culture in engineering education and has provided original empirical findings for the predominant educational approach, the analysis is inevitably limited in scope. For instance, an extended study could explore the linguistic patterns in more depth and detail, focusing on other keywords and relevant multiword units. Similarly, the discussion of implications for practice is brief; therefore, additional publications with more linguistic and practical foci are planned. Furthermore, the more nuanced approaches found in several of the articles analyzed merit further discussion, and we encourage readers to explore them in more depth. Moreover, we did not review/assess the quality of the research undertaken as such but rather concentrated on the underlying assumptions of the investigations and educational practices reported in the studies. It should also be noted that our data have an Anglophone bias and, therefore, may be seen as “Western-centric,” although this is somewhat unavoidable when analyzing international academic journals. While this research is not without limitations, our diverse team, from engineering, the humanities, and the social sciences based in four universities on three continents, hope that these findings and arguments will inspire critical engagement with this paper and this crucial area.

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APPENDIX

Here, we briefly summarize the 11 articles that did not clearly align with either of the two approaches in our close readings reported in Section 3.2. While several unclassified papers do not equate culture with nationality, implicit geographical conceptualizations of culture are common.

- Gilbert, D. J., Lehman Held, M., Ellzey, J. L., Bailey, W. T., & Young, L. B. (2015). Teaching “community engagement” in engineering education for international development: Integration of an interdisciplinary social work curriculum. *European Journal of Engineering Education*, 40(3), 256–266. <https://doi.org/10.1080/03043797.2014.944103>
Gilbert et al. discuss international work as that with people from different cultures but do not unequivocally equate culture with nationality. Attention is also given to “communities” and their traditions (particularly in lower- and middle-income countries) that may be affected by engineering projects.
- Heitmann, G. (2005). Challenges of engineering education and curriculum development in the context of the Bologna process. *European Journal of Engineering Education*, 30(4), 447–458. <https://doi.org/10.1080/03043790500213136>
Heitmann argues for the importance of intercultural understanding for success in the global labor market, recommending international student mobility programs to gain intercultural experience.
- Lohmann, J. R., Rollins, H. A., & Hoey, J. J. (2006). Defining, developing and assessing global competence in engineers. *European Journal of Engineering Education*, 31(1), 119–131. <https://doi.org/10.1080/03043790500429906>
Lohmann et al. provide a review of literature that deconstructs culture into several constructivist elements but proceed to analyze or discuss cases in which subjects gain international experiences abroad.
- Malheiro, B., Silva, M., Ribeiro, M. C., Guedes, P., & Ferreira, P. (2015). The European Project Semester at ISEP: The challenge of educating global engineers. *European Journal of Engineering Education*, 40(3), 328–346. <https://doi.org/10.1080/03043797.2014.960509>
Malheiro et al. do not theorize culture or define intercultural competence but are concerned about both “multicultural” and “multidisciplinary” issues in engineering education. Multicultural work includes typical examples of the culture-as-given approach such as working in geographically dispersed teams, working with people of different nationalities, and working in a foreign language. Multidisciplinary work includes examples of working with people from different occupational cultures (although the authors do not use this term or refer to culture in this sense).
- Wittig, A. (2013). Implementing problem based learning through Engineers Without Borders student projects. *Advances in Engineering Education* (Summer), 1–20.
In Wittig's study, students in New York broaden their cultural knowledge by exploring projects based in Honduras.

The following examples, while appearing to refer to “intercultural issues” in the culture-as-a-given approach, were counted as unclassified because their attention to culture is relatively peripheral to the focus of the paper and they lack sufficient information on what is meant by “intercultural.”

- Lappalainen, P. (2011). Development cooperation as methodology for teaching social responsibility to engineers. *European Journal of Engineering Education*, 36(6), 513–519. <https://doi.org/10.1080/03043797.2011.619648>
Lappalainen only briefly mentions challenges in incorporating culture or socio-cultural dimensions into training and educational materials.
- Leydens, J. A., & Schneider, J. (2009). Innovations in composition programs that educate engineers: Drivers, opportunities, and challenges. *Journal of Engineering Education*, 98(3), 255–271. <https://doi.org/10.1002/j.2168-9830.2009.tb01023.x>
Leydens and Schneider use the word *culture* to discuss the need for professional skills in the engineering curriculum (as opposed to functional utility).
- Oladiran, M. T., Uziak J., Eisenberg M., & Scheffer, C. (2011) Global engineering teams – A programme promoting teamwork in engineering design and manufacturing. *European Journal of Engineering Education*, 36(2), 173–186. <https://doi.org/10.1080/03043797.2011.573534>
Oladiran et al. note that engineers will need professional skills and language proficiency to work in multinational, intercultural, and geographically dispersed teams.
- Ratchev, S., Blackwell, R., & Bonney, M. (2002). Design of an Industrial Management course: Bringing together engineering and educational approaches. *European Journal of Engineering Education*, 27(1), 113–129. <https://doi.org/10.1080/03043790110100164>
Ratchev et al. only briefly mention challenges in incorporating culture or socio-cultural dimensions into training and educational materials.

Finally, some papers focused on specific issues such as gender (Ihsen & Gebauer, 2009) and second language ability (Gilleard and Gilleard, 2002), only mentioning cultural issues in conjunction with broader discussions in the paper.

- Gilleard, J., & Gilleard, J. D. (2002). Developing cross-cultural communication skills. *Journal of Professional Issues in Engineering Education & Practice*, 128(4), 187–200. [https://doi.org/10.1061/\(ASCE\)1052-3928\(2002\)128:4\(187\)](https://doi.org/10.1061/(ASCE)1052-3928(2002)128:4(187))
Gilleard and Gilleard focus on second language ability.
- Ihsen, S., & Gebauer, S. (2009). Diversity issues in the engineering curriculum. *European Journal of Engineering Education*, 34(5), 419–424. <https://doi.org/10.1080/03043790903137551>
Ihsen and Gebauer focus on gender issues.